Improving Directed Releases from NYC Reservoirs in the Upper Delaware River Basin

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Extended Abstract

The Delaware River Basin (DRB) supplies water to over 13 million people in four states. Historically, users in the Basin struggled to reach agreements on how to share the water in the Delaware River. In 1954, the U.S. Supreme Court issued a Decree (available at https://webapps.usgs.gov/odrm/about/decree) resolving State of New Jersey v. State of New York and City of New York and specifying how much water individual parties like New York City (NYC) or New Jersey State are allowed to divert from the DRB. It also established the position of Delaware River Master at the US Geological Survey (USGS) to administer the decision. On a day-to-day basis, the Delaware River Master models the expected flows of the Delaware River at Montague, NJ, designs the reservoir releases from the three NYC reservoirs that are needed to maintain established minimum flow objectives, directs NYC to make these releases, and compiles information needed to document these releases.

A system analysis team of USGS experts performed multiple analyses to look at the Delaware River Master directed release design process. The team determined which component improvements would result in the largest increases in flow objective compliance and provided insight into the system.

The relative contributions of five components of streamflow at the Delaware River at the USGS Montague, NJ, streamgage: (1) directed releases from NYC reservoirs, 2) conservation releases from the NYC reservoirs, 3) powerplant releases, 4) baseflow for the intervening flow between the powerplants and NYC releases and the Delaware River at Montague streamgage, and 5) runoff for the intervening flow between the powerplants and NYC releases and the Delaware River at Montague streamgage). The fraction of each component was then evaluated to determine the extent to which each component contributes to the total flow over the entire time period, by year, by month, and by four flow categories (total intervening streamflow (a) less than 1000 cfs, (b) between 1000 and 1500 cfs, (c) between 1500 and 2000 cfs, and (d) greater than 2000 cfs). The contribution of each component was then categorized by both their variability and magnitude to identify those components that are large contributors and highly variable. Baseflow was observed to be a substantial contribution to the total streamflow at Montague and low baseflow conditions appear to coincide with periods of directed releases. The contribution and variability of the powerplants to the total streamflow at Montague was low (~10 percent) across all years, months, and flows.

An evaluation was also conducted of baseflow and streamflow recession of the Delaware River at the USGS Montague, NJ, streamgage. The evaluation used daily streamflow data for the period 2010-2017 and hydrograph-separation and recession-curve analysis techniques provided in the USGS Groundwater Toolbox (Barlow et al, 2022). Contributions from reservoir releases to total streamflow measured at the streamgage were subtracted from the streamflow data to remove the reservoir component of daily discharge. Results of the hydrograph-separation analysis indicated that groundwater discharge is a substantial component of total streamflow at the gage, accounting for an average of about 56 percent of total natural streamflow (that is, streamflow without reservoir releases) for the 2010-2017 period. The recession analysis indicated that streamflow recessions at the streamgage can be modeled with the RECESS functionality of the Groundwater Toolbox by two characteristic master recession curves (MRCs): a "Summer" MRC that represents the lowest streamflow conditions from late June through mid October and a "Non-Summer" MRC that represents the remainder of the year.

A script that reproduces the directed releases design process was developed to evaluate the sources of error in the design process for the historical period 2010-2019. It was found that uncertainty in power reservoir and precipitation forecasts had small effects on the annually averaged directed releases errors, while the combined uncertainty in precipitation runoff and baseflow forecasts had a large effect. This led to an overall conclusion that the procedures for calculating runoff from precipitation forecasts and for forecasting baseflow are primary sources of directed releases error. The script was used to evaluate potential improvements to the design process. The RECESS master recession curve for use in forecasting baseflow was found to produce lower average DR errors when compared to existing approaches, though interannual variability in the errors were large and the RECESS approach was not optimal in every year evaluated.

Based on the analyses performed, future work of potential improvements to the design process will focus on the baseflow forecast and runoff from rainfall calculation.

References

Barlow, P.M., McHugh, A.R., Kiang, J.E., Zhai, T., Hummel, P., Duda, P., and Hinz, S., 2022. "U.S. Geological Survey Hydrologic Toolbox — A graphical and mapping interface for analysis of hydrologic data: U.S. Geological Survey Techniques and Methods", book 4, chap. D3, 23 p., https://doi.org/10.3133/tm4D3.